*NOTES ON STELLAR CLASSIFICATION.**

III.

BEARING in mind what has been said about the origin of the special class of bright line stars, I give a diagram showing that they occur exactly where we should expect to find them if the suggested origin is a sound one.

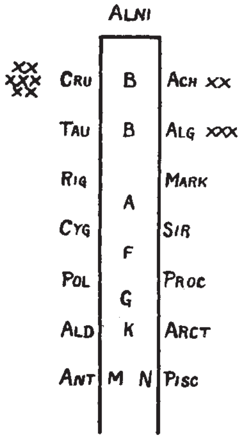

FIG. 5.—Position of the bright line stars at the top of the temperature curve.

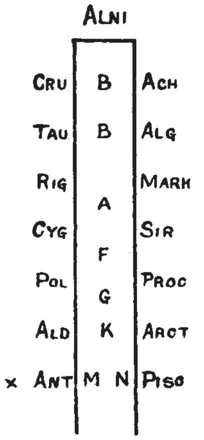

FIG. 6.—Position of the bright line variables at the base of the ascending arm of the temperature curve.

I return to that class of variable stars the changing luminosity of which, according to my hypothesis, is due to the heat and light produced by collisions between meteor swarms (Fig. 6).

Of these stars, in which the bright radiations have been recorded at maximum, one only, *o* Ceti, is included among the eighteen classified at Kensington as Antarian; 225 stars classified as Md (Antarian) are given on the Harvard List.[7] These are chiefly variables of long period. Prof. Pickering has obtained forty photographs showing bright lines, and ten stars have been discovered by means of this peculiarity of the spectrum.[8] Near minimum, when the star is faint, the bright lines are not seen.

There can be no doubt that all are physically similar, and that the position of all is at the base of the ascending arm of the temperature curve. That they are found here and nowhere else is an important test of the view that we have to deal with nebulous clouds consisting of discrete meteorites, as in comets, the gases from which produced by the heat supplied by collisions fill the interspaces at maximum and superadd the bright radiations to the fluting and line absorption seen at all times with varying intensity.

We next pass from these long-period variables with smooth curves, sometimes called "Mira variables," to another class with short periods, and with curves not so smooth, called "Cepheid variables."

The diagram Fig. 7 shows that these occur in the greatest number at a stage higher up the ascending branch of the temperature curve than the Miras. So far bright lines have not been recorded at maximum, but it has been noted that the position of maximum light energy moves towards the violet[9] as the star brightens. Their shorter periods, taken in connection with the fact that they must be more condensed than the Miras judging from their position on the curve, explains this difference of behaviour—there are no interspaces.

The Cepheid variables are not the only class without bright lines. I have already (Bull. I.) referred to the "eclipsing variables." Of these there are two classes, represented by β Lyræ and Algol, in which the shape of the curve is very different. This difference seems to arise from the fact that in the case of the Algols we are dealing with true discs, while in the case of the Lyras this stage has not been yet reached. These conditions are indicated by the position of the Lyras on the ascending and of the Algols on the descending arm of the curve.

Among the Piscian stars at the base of the descending arm we find a number distinguished by their irregular variability. In these we deal with a star rapidly dimming, surrounded by vapours of carbon giving absorption flutings, and of iron giving a multitude of absorption lines. The changes in the density of these vapours, to say nothing of the possible formation of scoriæ, are sufficient to explain the variation and irregularity in the light given out by these bodies. There are no interspaces to produce bright lines.

It is singular that some inquirers seem to regard the Antarian and Piscian stars (M and N) as being similar and so treat them as convertible terms, while the fact is that the only similarity is their temperature. The following table will indicate their dissimilarities:—

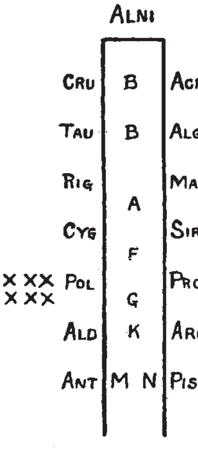

FIG. 7.—Position of the Cepheid variables halfway up the ascending arm of the temperature curve.

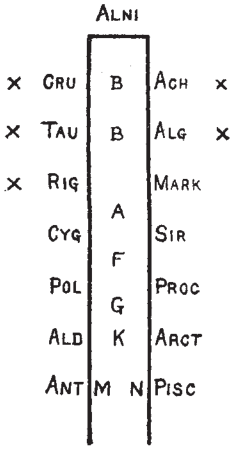

FIG. 8.—Position of the eclipsing variables towards the top of the curve.

Antarian.	*Piscian.*
Least condensed	Most condensed
Titanium absorption flutings	Carbon absorption flutings
Regular variables	Irregular variables
Bright lines	No bright lines

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* Continued from p. 619.

[7] *Annals*, vol. lv., pt. 1.

[8] *Astr. Nachrichten*, vol. clxxxvii., p. 1.

[9] Albrect in *Astrophysical Journal*, xxv., 332.

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I have before referred to Miss Maury's *c* and *b* "divisions." It is interesting to see how the stars composing them arrange themselves on the ascending and descending arms. The facts are given in Figs. 9 and 10.

Prof. Ejnar Hertzsprung[10] has discussed the divisions of Miss Maury's classification, and while he finds that there is no systematic relationship between the *a* and *b* divisions with regard to spectral differences and differences of brightness, yet it is otherwise in the case of the *c* and *ac* divisions. The *c* stars, he finds, are very distant, and are extraordinarily bright. According to him (and previously according to Miss Maury) they seem to suggest different physical constitutions from the other divisions, and he terms them "whales," while the other stars he considers as "fishes." In his paper he gives a list of twenty-four *c* and *ac* stars. All of these included in my catalogue, with two exceptions probably due to errors of classification, fall on the ascending arm of the temperature curve (see Fig. 9).

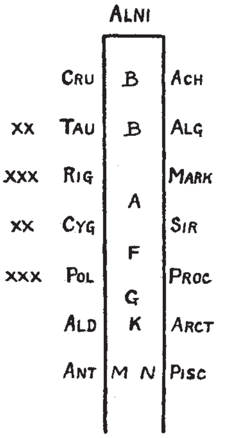

FIG. 9.—Position of the "*c*" stars on the ascending arm.

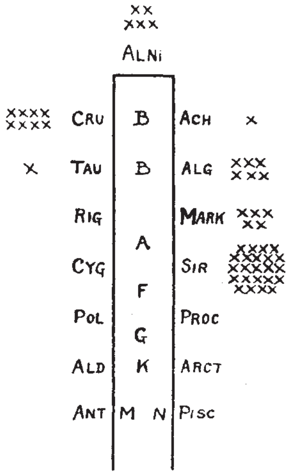

FIG. 10.—Position of the "*b*" stars at the top of the temperature curve and on the descending arm.

They are thus found to be condensing swarms following in a natural sequence the more sparse swarms so rich in variables of the *o* Ceti type.

Their great luminosity is due more to volume than to temperature, and the special characteristics of the lines, as opposed to those of the *a* division, are due to the difference in absorbing conditions in sparse swarms and bodies with forming atmospheres, and also to the fact that the "solar" lines only occur in stars of lower temperature.

The stars of type "*b*," on the other hand, are seen to arrange themselves in an orderly sequence following on those of type "*c*" (Fig. 10). At the top of the ascending arm, where the sequence of *c* stars ends, the *b* stars come in, and extend round through the top of the curve down to the Sirian stage on the descending side. This sequence of the *b* on the *c* stars is a very suggestive one. As a *c* star approaches its maximum temperature, the physical conditions change from those giving rise to type *c* spectra to those from which spectra of type *b* are produced.

We are now in a position to derive some material results from the preceding considerations. In view of the definite manner in which the physical properties considered have shown themselves to be associated with the various groups on one arm of the curve or the other, we are justified in using these physical properties as criteria for locating stars on the ascending or descending arm of the temperature curve.

In the case of the constant bright line stars, Fig. 5 shows that considerations of their physical conditions may be made under the probability that all these bodies are in the neighbourhood of the maximum temperature attained during their evolution. Thus the twenty-six bright line stars mentioned earlier as being contained in the Harvard lists may be considered as being located on the temperature curve.

On the Harvard scheme, with the exception of classes M and N, stars may belong to either, as increasing and decreasing temperatures are neither recognised nor provided for. In classes M and N, as in my hypothesis, we are dealing with the bottoms of the ascending and descending branches, lowest temperatures and vastly differing conditions are involved. Hence we can classify as Antarian or Piscian all stars designated M or N on the Harvard system. We thus obtain from the Harvard Revised Photometry and the Second Catalogue of Variable Stars, about 650 and 70 of these two classes respectively.

Next, regarding the Cepheid variables, the Harvard Second Catalogue of Variable Stars contains thirty-four short period variables with approximately solar spectra. These are Cepheid variables, and may all be placed on the ascending arm, in conformity with the six already classified.

With regard to the eclipsing variables, those with continuously varying light-curves, like that of *β* Lyræ, will probably lie on the ascending arm of the temperature curve, and those like Algol may be expected to occur on the descending branch.

Finally we have to deal with the "c" and "b" stars. From the manner in which the ten of Miss Maury's Type "c" stars, which have been classified at Kensington, aggregate on the ascending arm, we may place the remaining nine given in her tables[11] in corresponding positions.

From the same source we find about ninety stars of Type "b." Those classified at Kensington are seen to cluster round the top of the curve, and to extend down the descending arm. Hence, when considering the physical conditions of those not so classified, we may regard them as occupying similar positions.

We are thus able to add nearly 900 stars to the 470 already classified on the temperature basis at Kensington.[12]

NORMAN LOCKYER.

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[10] *Astr. Nachrichten*, vol. clxxix., No. 4296, p. 374.

[11] Annals Harv. Coll. Obs., vol. xxviii., part i.

[12] Catalogue of 470 of the brighter stars.

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